Polarimetric remote sensing in oxygen A and B bands: sensitivity study and information content analysis for vertical profile of aerosols

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Theoretical analysis is conducted to reveal the information content of aerosol vertical profile in space-borne measurements of the backscattered radiance and degree of linear polarization (DOLP) in Oxygen (O_2) A and B bands. Assuming a quasi-Gaussian shape for aerosol vertical profile characterized by peak height H and half width γ (at half maximum), the Unified Linearized Vector Radiative Transfer Model (UNL-VRTM) is used to simulate the Stokes 4-vector elements of upwelling radiation at the top of atmosphere (TOA) and their Jacobians with respect to H and γ. Calculations for different aerosol types and different combinations of H and γ values show that the wide range of gas absorption optical depth in O_2 A and B band enables the sensitivity of backscattered DOLP and radiance at TOA to the aerosol layer at different altitudes. Quantitatively, DOLP in O_2 A and B bands is found to be more sensitive to H and γ than radiance, especially over the bright surfaces (with large visible reflectance). In many O_2 absorption wavelengths, Degree of Freedom for Signal (DFS) for retrieving H (or γ) generally increases with H (and γ) and can be close to unity in many cases, assuming that the composite uncertainty from surface and aerosol scattering properties as well as measurements is less than 5%. Further analysis demonstrates that DFS needed for simultaneous retrieval of H and γ for high-lofted aerosol profiles (H > 2 km) can be obtained from a combined use of DOLP measurements at ~10 O_2 A and B absorption wavelengths. However, challenges still remain for resolving aerosol profiles with H less than 2 km. Future hyperspectral measurements of DOLP in O_2 A and B bands are needed to continue studying their potential and their combination with radiance and DOLP in atmospheric window channels for retrieving the vertical profiles of aerosols, especially highly scattering aerosols, over land.

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